

AWARD NUMBER: W81XWH-14-1-0113

TITLE: A Modular Set of Mixed Reality Simulators for “blind” and Guided Procedures

PRINCIPAL INVESTIGATOR: Samsun Lampotang, PhD

CONTRACTING ORGANIZATION: University of Florida
Gainesville, FL 32611

REPORT DATE: August 2016

TYPE OF REPORT: Annual

PREPARED FOR: U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

DISTRIBUTION STATEMENT: Approved for Public Release;
Distribution Unlimited

The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision unless so designated by other documentation.

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.					
1. REPORT DATE (DD-MM-YYYY) August 2016		2. REPORT TYPE Year 2 Annual Report		3. DATES COVERED (From - To) 08/01/2015 - 07/31/2016	
4. TITLE AND SUBTITLE A Modular Set of Mixed Reality Simulators for "Blind" and Guided Procedures				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER W81XWH-14-1-0113	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Lampotang, Samsun. Gifford, Andrew. Lizdas, David. email: slampotang@anest.ufl.edu				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of Florida 207 Grinter Hall Gainesville, FL 32611-0001				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Medical Research and Materiel Command Fort Detrick, Maryland 21702-5012				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION / AVAILABILITY STATEMENT Approved for Public Release; Distribution Unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT Development of the Regional Anesthesia (RA) and Central Venous Access (CVA) mixed reality simulators is ahead of schedule. In their current state, the RA and CVA simulators are ready to be delivered to DoD, both exceeding original specifications. See http://simulation.health.ufl.edu/research/ra_sim.wmv . A completed study of the CVA simulator indicated a need for instruction while using the simulator and a curriculum. A manuscript is being finalized for submission to Anesthesia & Analgesia as a peer-reviewed publication. RA and CVA simulators were evaluated at USN MC, Walter Reed, BAMC, Wilford Hall, VA SimLearn. About 780 persons used the simulators. Accomplishments beyond the original deliverables include (a) design, implementation and ongoing evaluation (IRB- and HRPO-approved learning outcome study) of an integrated tutor (IT) for the RA simulator, (b) an IT editor developed to facilitate creation by non-technical educators of ITs for the set of modular simulators, (c) a curriculum for self-study and self-debriefing in austere environments, also suitable for civilian use, (d) output from the set of modular simulators has been made SCORM/xAPI-compliant to facilitate eventual integration with learning management systems and (e) SMARTS (System of Modular Augmented Reality Tracked Simulators) rapid simulator development platform with software plug-ins, interoperable tracked tools and modular stand.					
15. SUBJECT TERMS Integrated tutor, Plug-ins, Outcomes studies, Rapid simulator development platform					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			USAMRMC
U	U	U	U	37	19b. TELEPHONE NUMBER (include area code)

Table of Contents

	<u>Page</u>
1. Introduction.....	2
2. Keywords.....	2
3. Accomplishments.....	3
4. Impact.....	28
5. Changes/Problems.....	28
6. Products.....	29
7. Participants & Other Collaborating Organizations.....	33
8. Special Reporting Requirements.....	34
9. Appendices.....	N/A

ANNUAL REPORT

A Modular Set of Mixed Reality Simulators for “Blind” and Guided Procedures
Award W81XWH-14-1-0113

Author: Samsun (Sem) Lampotang, PhD, PI; slampotang@anest.ufl.edu



This annual report covers only the 3-year (8/1/2014 – 7/31/17) Phase I of award W81XWH-14-1-0113 “A Modular Set of Mixed Reality Simulators for “Blind” and Guided Procedures”. It does NOT cover the optional 2-year (8/1/2017 – 7/31/2019) Phase II period.

INTRODUCTION:

We are ultimately developing and delivering a modular set of five mixed reality/augmented reality (AR) simulators, each for a different application from a set of five “blind” and guided medical procedures: (1) Regional Anesthesia (RA), (2) Central Venous Access (CVA), (3) External Ventricular Drain (EVD; aka Ventriculostomy), (4) Chest Tube Insertion and (5) TransRectal UltraSound (TRUS)-Imaged, Manually-Guided Needle Biopsy of the Prostate. The AR is through visual augmentation, i.e., providing 3D, real-time, color visualization of the relevant anatomy, tools, cognitive aids and implements. Our purpose is to provide deployed and Stateside medical military personnel and also civilian reservists and clinicians compact, lightweight, turnkey simulators designed to work in austere environments. These highly-portable/deployable simulators are designed to provide the ability to acquire/maintain skills in medical procedures, some of which may be specific to military medicine and therefore unfamiliar to reservists who practice primarily civilian medicine. The ultimate purpose is to provide through the military medical personnel trained via our simulators safer and better quality care (as measured by our proposed patient outcomes study) to US military personnel (deployed and Stateside) and veterans. The scope of this research is deliberately wide; because the simulators are anatomic, they are not specific to military medical needs or protocols and can be readily repurposed for civilian medical training needs too. In addition, the modular nature of the system design (including the modular stand) will allow ready implementation of new mixed/augmented reality simulators beyond the original five to be delivered to DoD.

KEYWORDS:

Integrated tutor, Plug-ins, SMARTS (System of Modular Augmented Reality Tracked Simulators) rapid simulator development platform, Needs assessment, Outcomes studies (learning, behavior, results, RoI), Augmented reality procedural simulators, Mixed reality, Modular, Turnkey, Ultrasound imaging, Visual augmentation

ACCOMPLISHMENTS:

Major Goals and Objectives

The major goals and objectives for Phase I are:

- Needs assessment for a set of 5 mixed reality procedural simulators:
 - Regional Anesthesia (RA)
 - Central Venous Access (CVA)
 - External Ventricular Drain (EVD; aka Ventriculostomy)
 - Chest Tube Insertion
 - Trans Rectal Ultra Sound (TRUS)-Imaged, Manually-Guided Needle Biopsy of the Prostate (exchanged for the FAST trainer with approval from DoD)
- Build/integrate simulated US imaging into modular simulator design
- Design/build/evaluate/refine modular stand that will be common to the 5 different simulators (and other potential future simulators) to be delivered to DoD
- Design 4 outcome studies (based on the Kirkpatrick levels) with UF IRB and also HRPO oversight and approval:
 - Learning (Kirkpatrick Level 2)
 - Transfer to Clinical Practice (Kirkpatrick Level 3)
 - Patient Outcomes (Kirkpatrick Level 4)
 - Return on Investment – ROI (“Kirkpatrick Level 5”, aka Kirkpatrick/Phillips)
- Design, build, quality control, deliver to DoD during Phase I:
 - Phase I Regional Anesthesia (RA) simulator
 - Phase I Central Venous Access (CVA) simulator

Accomplishments Relative to Major Goals & Objectives

- Needs assessment has been completed for the RA and CVA simulators. Needs assessment is 70% complete for the EVD simulator and 50% complete for the prostate biopsy simulator. The needs assessment for the chest tube insertion simulator is 50% done.
- Simulated Ultrasound (US) imaging has been implemented and integrated into the modular simulator design. Status: 100% completed and deployed; beta tested at 4 military sites (Naval Medical Center, San Diego; Walter Reed National Military Medical Center, Bethesda; Brooke Army Medical Center, San Antonio; Wilmington Delaware VA Medical Center). A simulated US probe was designed to house a 6-DoF tracking magnetic sensor and 3D printed. The simulated US image is generated on-the-fly according to fundamental principles, from the intersection of an insonation plane with the 3D object being insonated to create a 2D cross-section. A virtual representation of the US probe was also created in the 3D visualization; a thin red sheet emanating from the long axis midline of the US probe represents the insonation plane and makes the invisible insonation plane visible in the 3D visualization. Pressure sensors (actually force sensitive resistors, FSRs) are placed on the face of the simulated US probe and help to determine how hard the user is pressing the US probe onto the skin. Based on the applied pressure/force, collapsible structures such as veins are seen to deform in the simulated US image and also in the 3D visualization. In addition, anisotropy was implemented in the simulated US image. Anisotropy is the property where depending on the angle of incidence of the insonation to the surface being insonated all or most of the US energy bounces away from, instead of back towards the probe, rendering objects that are in the insonation plane “invisible” or degrading their image in the simulated US image. The online video at http://simulation.health.ufl.edu/research/ra_sim.wmv shows how simulated ultrasound (US) imaging has been implemented and integrated into the modular AR simulator design. See for example the video frames from 0:09 to 0:15. The simulated US image can occupy the entire

screen or be combined with a 3D, color, real-time visualization. Anisotropy can be toggled on or off via the simulator user interface (UI) implemented on a right hand column on the screen of the laptop computer. Anisotropy can be readily turned off when using the simulator in “training wheels” mode with novices.

- A modular stand has been successfully designed, built and demonstrated at multiple venues and meetings. Status: 100% completed and deployed; beta tested at 4 military sites. See photo in Figure 1 below that shows a completed modular stand with a modular upper thorax anatomical block installed. Figures 2a – 2c show three other anatomical blocks that will mount onto the modular stand. Figure 2d shows the modular stand by itself. The modular stand holds a tracker unit at the bottom. The anatomical module base has a mechanical indexing groove that indexes and registers the anatomical block module to the tracker on the underside of the modular stand. The legs of the modular stand fold for compact packing in its mil spec padded transport case (Thermodyne).



Figure 1. The modular stand is on the right of the photo. It is shown in the thoracic regional anesthesia simulator configuration, i.e., with an RA anatomical module representing the posterior upper thorax snapped and indexed into the modular stand. Thoracic paravertebral blocks (TPVBs) and other regional anesthesia techniques can be practiced, acquired and maintained via this completed RA simulator. Towards the middle of the photo, the tool tray (black sponge with precision cutouts for holding tracked tools) includes the simulated ultrasound (US) probe on the right (off white color). A Tangible User Interface (TUI) for controlling the virtual camera is in the middle of the sponge tray (white rectangle with blue button). The TUI is fitted with a 6-DoF sensor that allows the virtual camera to be intuitively controlled by the user along 6-DoF. The blue button when pressed makes the virtual camera follow the TUI in space as the TUI is moved by the user. The user observes the 3D visualization on the laptop computer screen in real time to control the virtual camera position. When the user is satisfied with the virtual camera position, i.e., the perspective of the 3D visualization, the blue button on the TUI is released. On the left of the tool tray, three items are placed horizontally. The top item is a tracked needle encased in a protective sheath to protect users from its sharp tip. In the middle is a syringe for use with the needle. At the bottom is a marker pen that is used to mark the simulated skin when using US imaging assistance. At the left of the picture is a generic laptop (Acer) purchased at Best Buy with standard CPU, RAM, video RAM and graphics card (i.e., not a high end laptop)

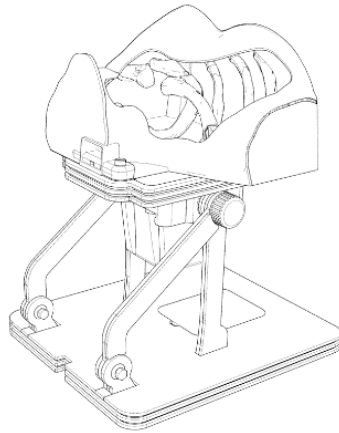


Figure 2a. Left CAD drawing: CVA Module on Modular Stand with Quick Release Latch; Right photograph: 3D printed anatomically correct shells, the one on the left has been painted and includes a puncturable skin that feels like skin. The one on the right has just been received from the 3D print vendor; the indexing plate has been rotated by 90° in the new print based on user feedback.

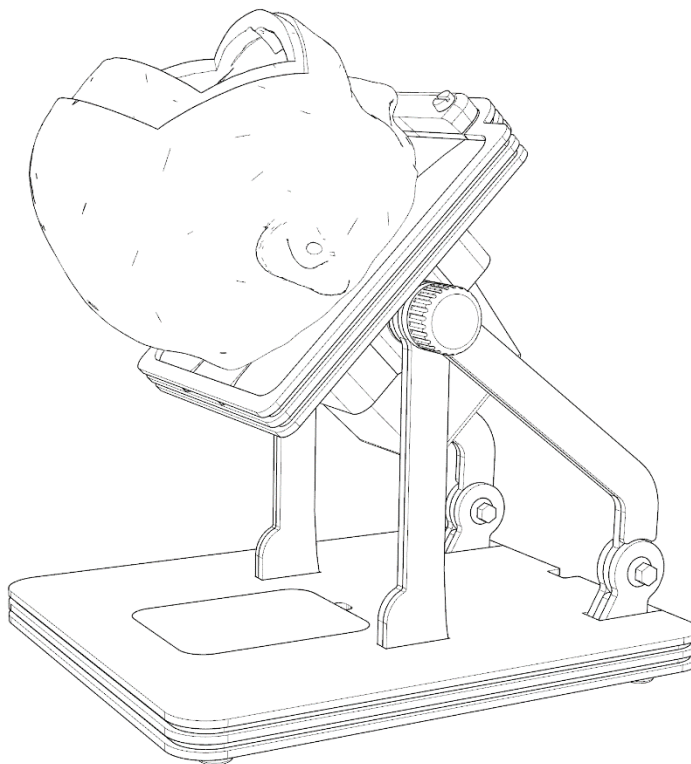


Figure 2b. External Ventricular Drain (EVD; a.k.a. ventriculostomy) Module on Modular Stand

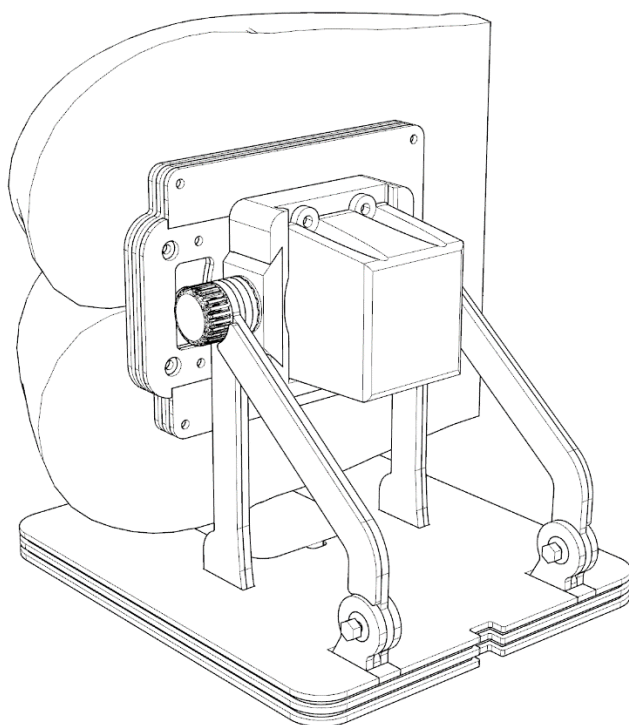


Figure 2c. TRUS-Guided Manual Prostate Biopsy Module on Modular Stand with Quick Release Latch

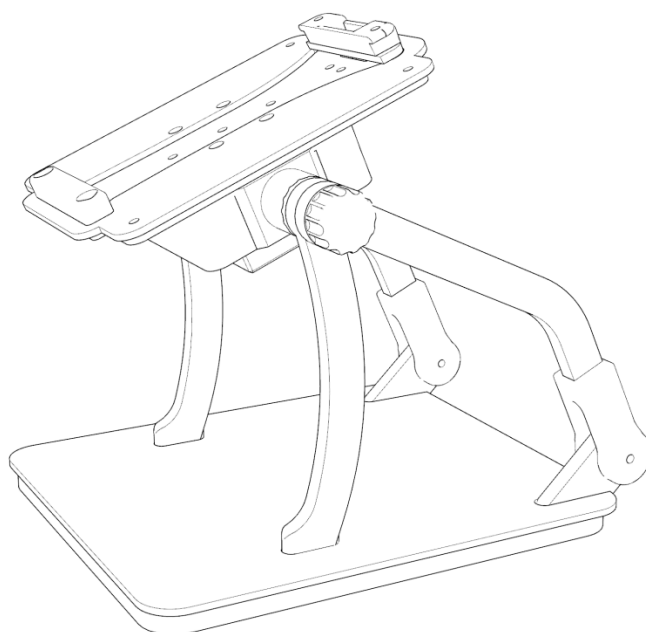
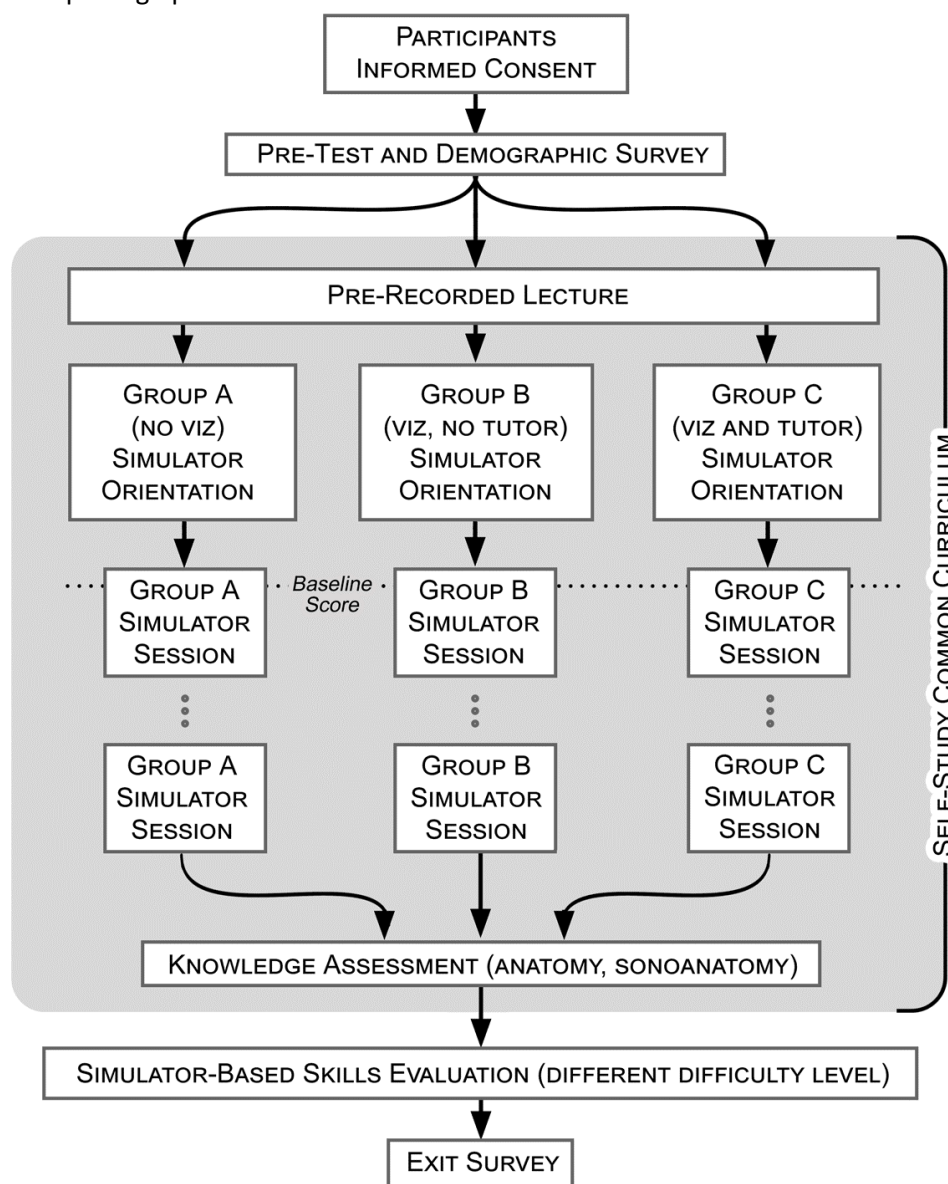


Figure 2d. The modular stand without an anatomical block and the indexing groove visible.

- Four outcome studies (4 total: 3 learning outcome, 1 patient outcome) are currently in various stages of completion)
 - UF IRB02 Approval Number 2014-U-0658. HRPO Log Number A-18036. RA simulator. A learning outcome study (per flowchart below) that investigates whether training with the RA simulator affects skill in performing thoracic paravertebral blocks (TPVB) had already been approved by UF IRB 02 prior to the 8/1/14 start of award W81XWH-14-1-0113 and was subsequently also approved by HRPO on 7/31/15. A revision to 2014-U-0658 was approved by IRB-02 on 4/28/2016. Continuing review of 2014-U-0658 was approved by IRB-02 on 6/3/2016 and subsequent revision was approved 7/11/2016. First participant of the study occurred on 6/21/2016. Seven anesthesia residents had participated in the study on 8/31/16 and the rate of resident and fellow recruitment is now picking up.



- UF IRB02 Approval Number 2015-U-0672. HRPO Log Number A-18036.2. RA simulator. A second learning outcome study that will investigate whether training with the RA simulator affects skill in performing a modified thoracic paravertebral block (Sagittal

Paramedian Oblique TPVB) was approved by UF IRB 02 on 1/13/16. Revision approved by IRB-02 on 4/28/2016. HRPO Approval obtained on 4/5/16. No participants have been enrolled in study 2015-U-0672 at the time of writing this yearly report. The modified TPVB technique is depicted in Figure 3 below and was presented by Lampotang at the American Society of Anesthesiologists October 2015 annual meeting in San Diego, CA. *Ihnatsenka B, Le-Wendling L, Coleman CJ, Lizdas DE, Lampotang S: A mixed reality simulator augmented with real-time 3D visualization helps develop a modified thoracic paravertebral block*

- UF IRB02 Approval Number **2013-U-1025**. CVA simulator. A third learning outcome study for the CVA simulator was approved by UF IRB02. This third study investigates whether training with the CVA simulator affects skill in central venous access via three different approaches: (a) the internal jugular, (b) the infraclavicular approach to the subclavian vein and (c) the supraclavicular approach to the subclavian vein. We were informed that our proposal to DoD had been awarded in October 2013 but were instructed not to assume we would actually receive the funds until we received formal written notification that we could start working on the grant. Written authorization was eventually obtained to formally start work on August 1, 2014 on the DoD grant. We did not have clear line of sight in the first half of 2014 regarding when the DoD Grant would officially start and subsequently trigger the need for HRPO approval. Given that we already had UF IRB02 oversight and approval, we enrolled consenting participants and started the study prior to 8/1/2014, the start date of award W81XWH-14-1-0113. We started the study without DoD secondary level review from HRPO because at the time we did not need such HRPO oversight and approval since we were not yet officially funded by DoD.
- IRB201601147 – Mixed Reality Simulation Training for Central Venous Access (CVA): An Analysis of Retrospective Patient Outcomes. CVA Simulator: Retrospective Study of Patient Outcomes at UF Health – Initial UFIRB 01 submission of patient outcome study occurred on 7/26/16. We will modify our study protocol based on IRB correspondence until approval is obtained.

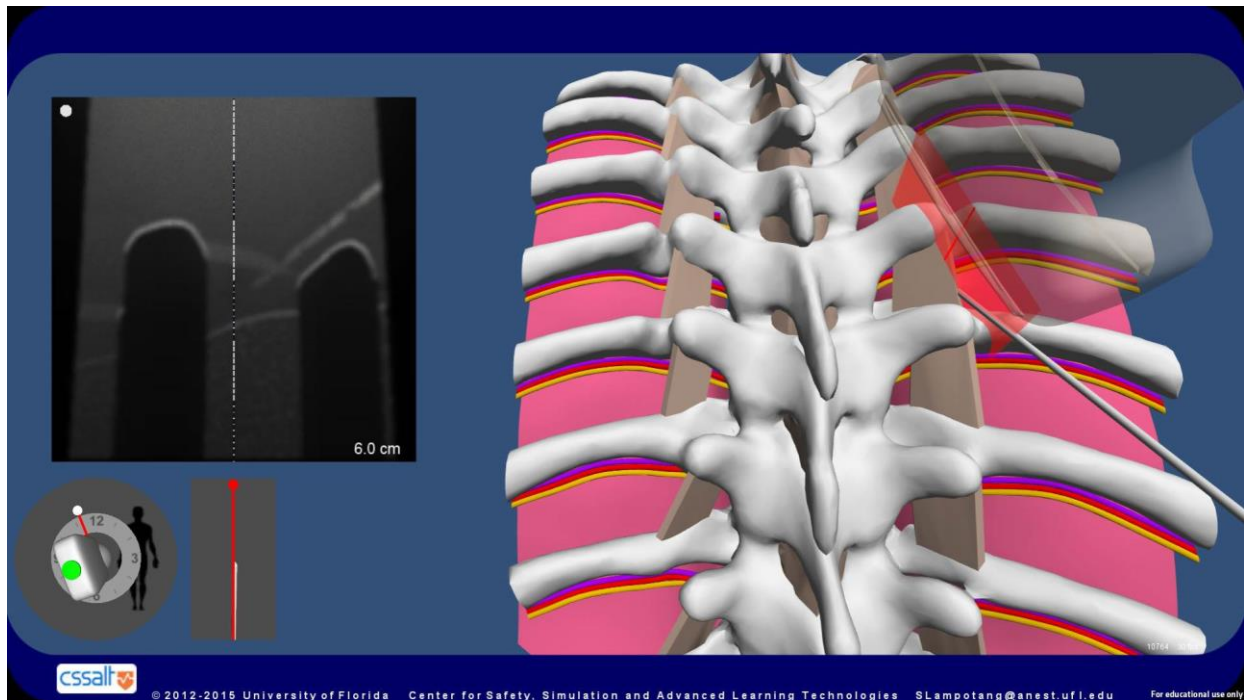
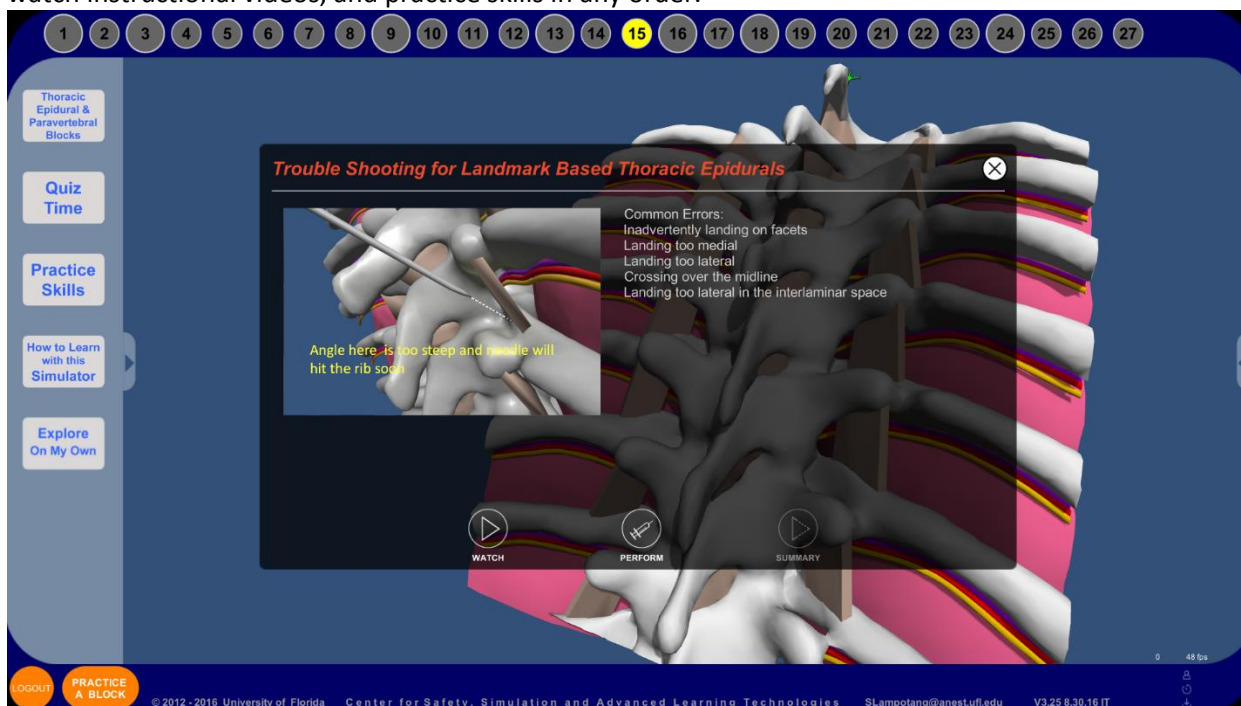


Figure 3. The development of a modified thoracic paravertebral block (TPVB) technique was facilitated by the 3D visual augmentation (visualization) provided by the simulator. The tracked needle is seen in the gray scale simulated US image at the top left of the figure. The two ribs cast dark shadows. The ligament is visible on top of the lung (both structures span the two ribs) in the simulated ultrasound image. The 3D visualization is on the right of the picture and its perspective is controlled by the user or instructor via a virtual camera TUI. A phantom of the US probe based on the actual 6-DoF position of the simulated and tracked physical US probe is also visible in the 3D visualization.

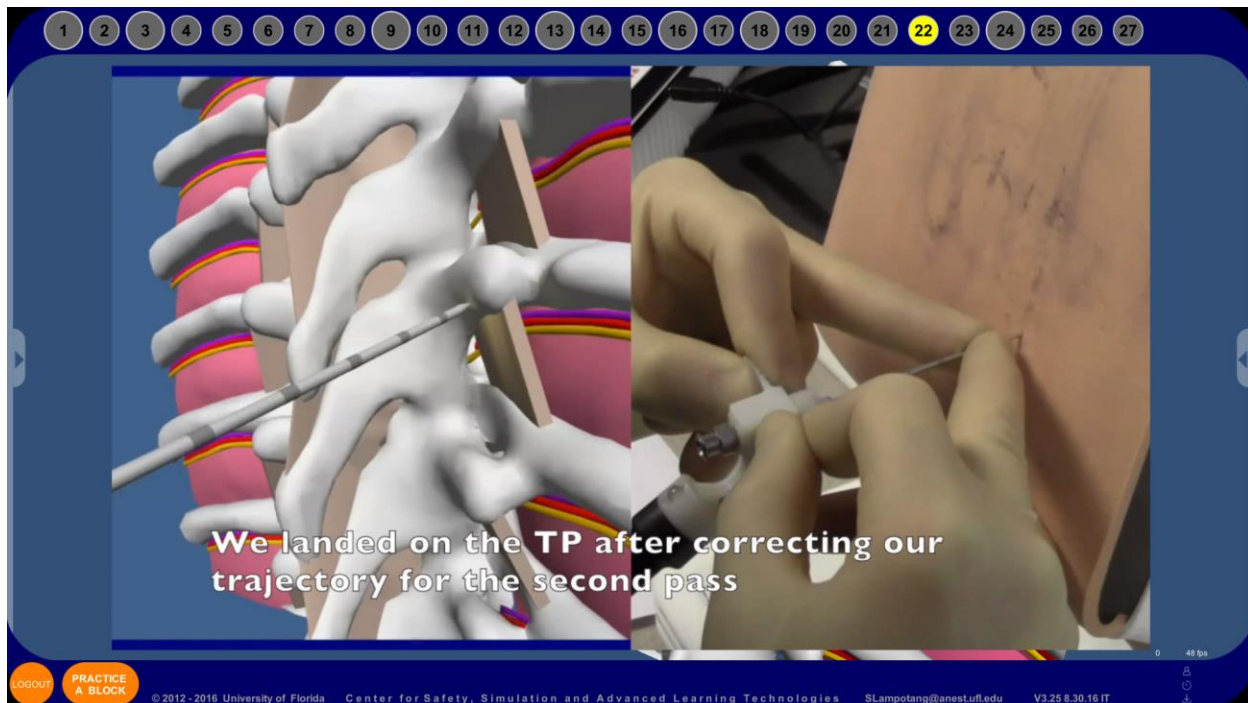
- We have started the process of reconfiguring the entry fields in our Electronic Medical Record (EPIC) to allow us to collect data regarding central venous access procedures and associated complications such as inadvertent pneumothorax and arterial puncture for the Phase II patient outcome studies.
- The Phase I RA simulator is ready (ahead of schedule) and has been beta tested by 4 military medical institutions and subject matter experts (SMEs). 100% completed; target and deliverable exceeded. See the online video at http://simulation.health.ufl.edu/research/ra_sim.wmv
- The Phase I CVA simulator (as defined in the original proposal, i.e., without an integrated tutor) was completed before the end of Year 2 (also ahead of schedule) and was also beta tested at 4 military medical institutions and SMEs. 100% completed.

Accomplishments Above and Beyond Original Specific Deliverables

1. **Integrated Tutor:** Based on preliminary, not yet published results from a completed learning outcome study on the CVA simulator, we developed in Year 2 an integrated tutor to facilitate self-study and self-debriefing with our line of AR procedural simulators. The integrated tutor was first instantiated for the RA simulator. We developed software that inserts a variety of instructional materials into the simulation, including videos, simulation settings, screen captures of the 3D visualization, and optional custom programs for specialized learning objectives. Users can browse, watch instructional videos, and practice skills in any order.

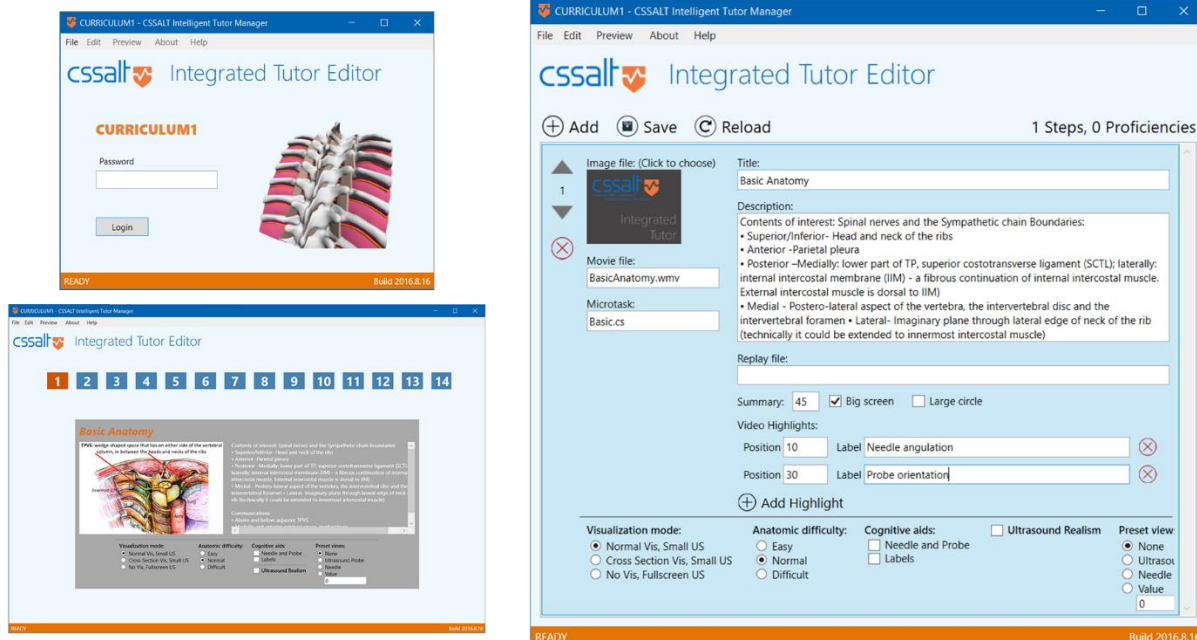


Screenshot of a menu from the integrated tutor for the RA simulator



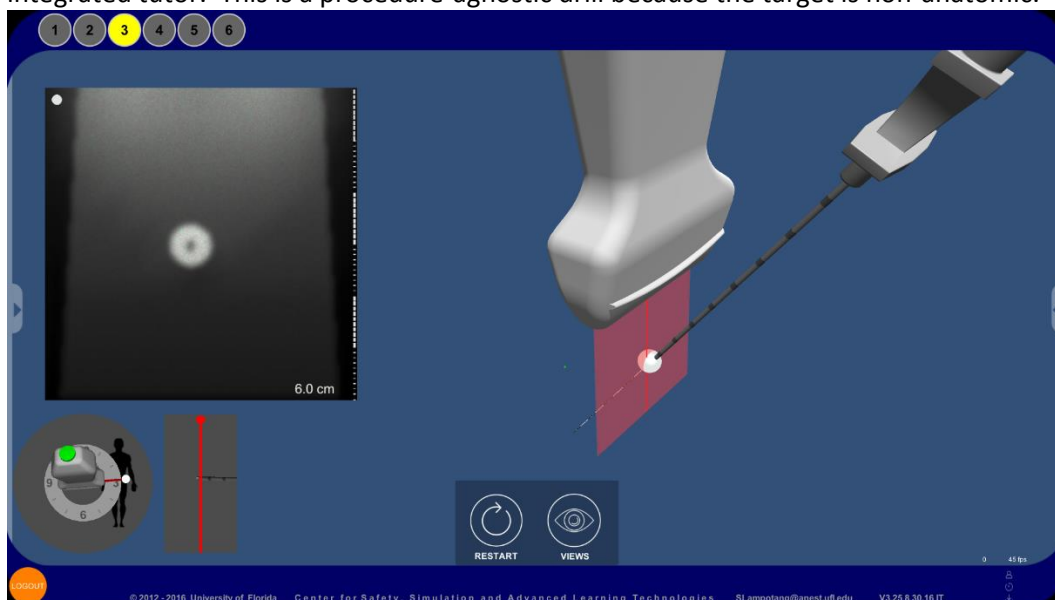
Split screen on integrated tutor for RA simulator: Left half: screenshot of display; Right half: screenshot of video playing for same procedure at exact same point in time

2. **Curricula:** Two detailed curricula for the RA simulator were developed for US-guided and US-assisted thoracic paravertebral blocks and US-assisted and landmark-based epidurals. This includes an hour of instructional videos; however, they are not presented all at once. Combined into one curriculum in the outcome study, they are split up into digestible sections or modules. The curricula are at <http://vam.anest.ufl.edu/rastudy2016/>
3. **Integrated Tutor Editor:** We realized we would need integrated tutors for all future AR simulators and created an integrated tutor editor to provide an environment to facilitate design and repurposing of existing integrated tutors for other procedures. We developed a way to enable clinicians, volunteers, non-developers (or anyone without programming background) to design and build intelligent tutor steps. The editor enables the clinical team to create and edit content that interacts with the AR simulators. First implemented for the RA simulator and being used in the ongoing learning outcome study (UF IRB02 Number 2014-U-0658. HRPO Log Number A-18036), the editor is being applied at the moment to design and implement an integrated tutor for the CVA simulator.



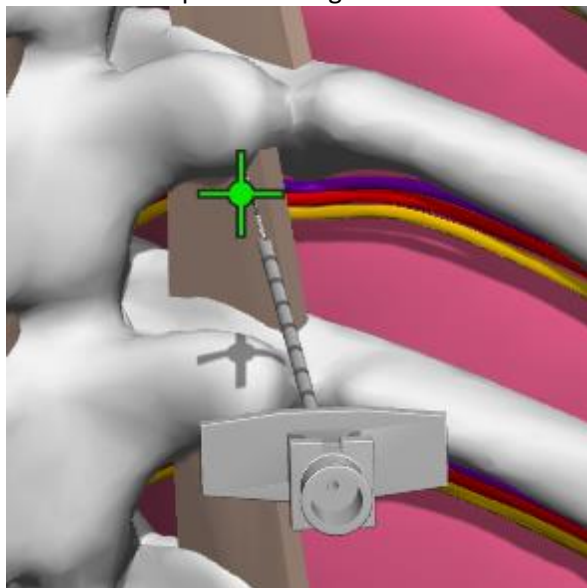
4. **Skill Scripts:** We created six self-contained exercises within the integrated tutor for the RA simulator that allow learners to temporarily pause the larger AR simulation and focus on practicing specific skills. The skill scripts are:

- a. Needling Target Exercise. The virtual thoracic anatomy is removed and replaced with a small spherical target in the phantom. The user practices needling that target with any style of ultrasound guidance or assistance. The location of the target is randomly changed by the integrated tutor. This is a procedure-agnostic drill because the target is non-anatomic.

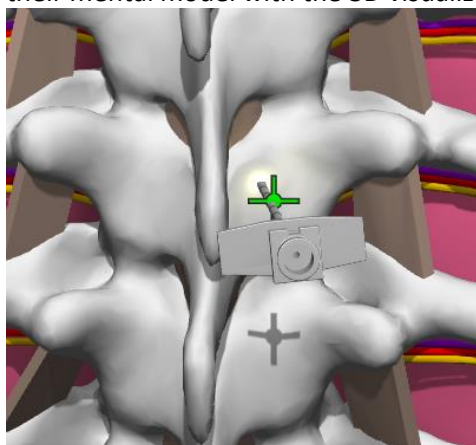


- b. Marking the skin puncture point for thoracic paravertebral blocks. Learners set all else aside and focus on this important step of the curriculum. The learners' skin puncture point is

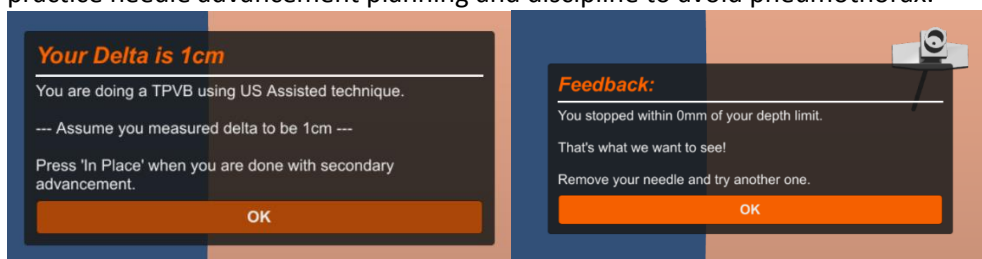
compared with the curriculum's ideal point. Side and level are specified and change each time. This is a procedure-agnostic drill because the target is only on the skin.



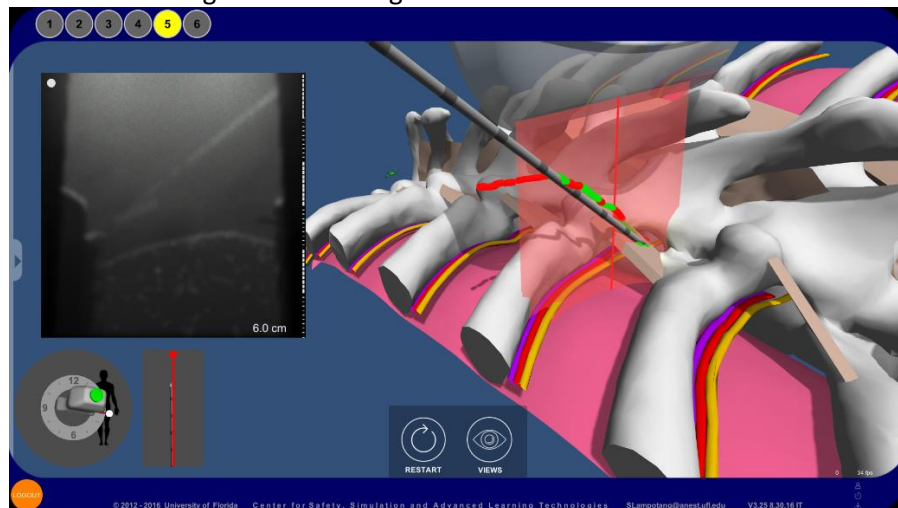
- c. Bone palpation exercise for thoracic epidurals. A skin puncture point is randomly specified by the integrated tutor and rendered on the virtual skin. It is not always at an ideal location. Users enter the skin at that specified point, palpate the bone with the needle, then compare their mental model with the 3D visualization, as shown below.



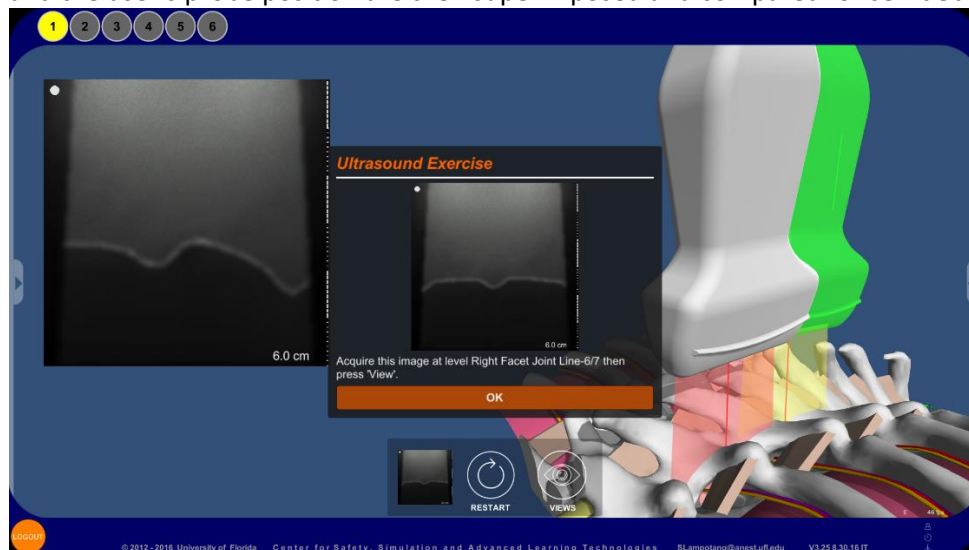
- d. Secondary Advancement. A skill specific for US-assisted thoracic paravertebral blocks: users practice needle advancement planning and discipline to avoid pneumothorax.



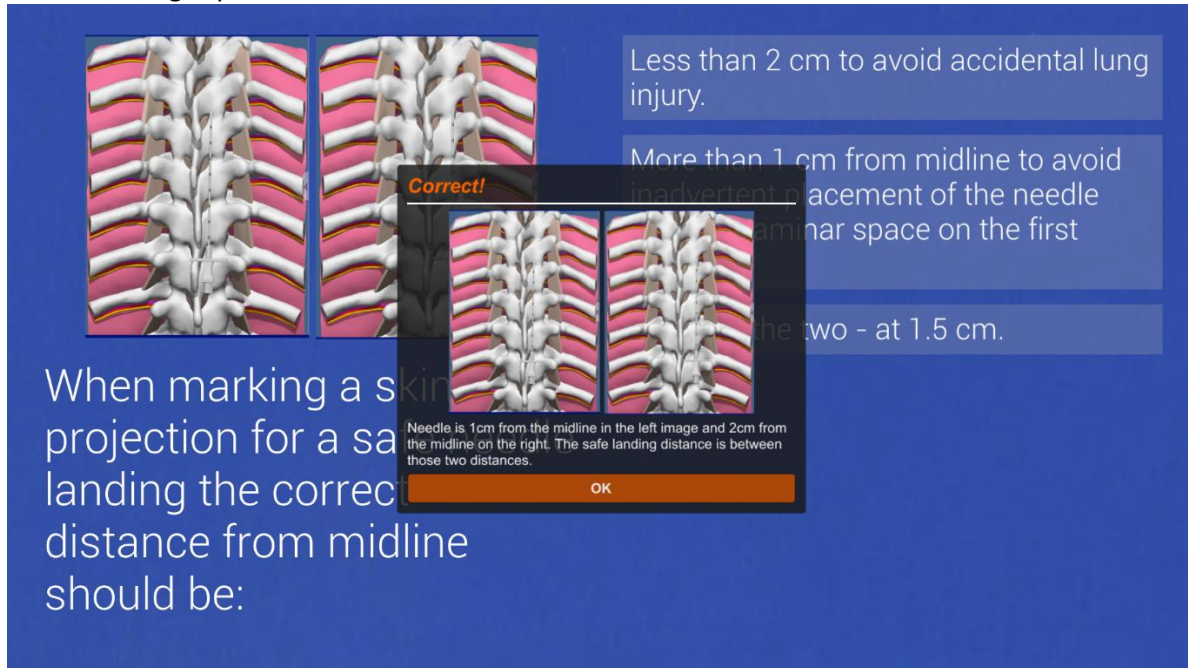
- e. In-plane needling skill: Users practice ultrasound-guided in-plane needling techniques. The needle path is color-coded for debriefing; green indicates that the needle tip is visible in the US image while advancing; red indicates the needle was advanced while the tip was not visible in US image. Procedure agnostic.



- f. Ultrasound image acquisition: users are given an ultrasound image and tasked with reproducing that image with their simulated ultrasound. The given images' probe position and the user's probe position are then superimposed and compared for self-debriefing/AAR.

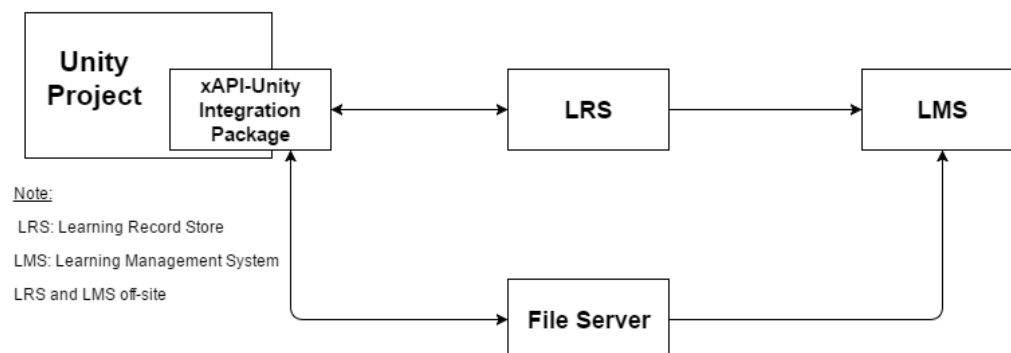


5. **In-simulation quiz:** a modular quiz element was added to the integrated tutor engine to add variety to the learning experience.



6. **Homework materials** common to all groups of the learning outcome study currently underway for the RA simulator are available at <http://vam.anest.ufl.edu/rastudy2016/>
7. **SCORM/xAPI Compatibility:** Based on interactions during the 2016 IPR at Ft. Detrick, the simulator output has been made xAPI-compliant so that its output will be compatible with an architecture such as the one below. We developed a software plug-in for our mixed reality software that can communicate with an xAPI-compatible learning record store (LRS) and learning management system (LMS). The plug-in has been tested, documented, and is ready to be installed.

xAPI-Unity Integration Package Flowchart



8. **Advanced Scoring Algorithm:** Specific scoring elements were added for US-assisted thoracic paravertebrals and epidurals, US-guided thoracic paravertebrals, and landmark-based epidurals. We created an easy to read feedback element to the scoring algorithm which hides much of the details from the user.

Practice your skills

Choose a technique you want to use for your practice session and then click the type of procedure.

☒ Ultrasound Assisted
 ☐ Ultrasound Guided
 ☐ Landmark

Paravertebral Epidural

Time Out...

We will perform a TPVB on the Left side on level T6.

Use ultrasound assisted technique.

OK

Filename: RA-2016-08-31_04-37-45-PM.txt

Participant:

Group:

Comments:

The score for this block is 1212 out of 1500. Anything over 1200 is considered satisfactory. Our curriculum-based scorer found the following:

The requested block was a USAssisted Left ThoracicParavertebral at T6.

You punctured the Left T7 Superior Costotransverse Ligament.

Your time was good - now can you do it in less than 120 seconds?

We detected more needle passes than necessary. Try to reduce the number of needle passes.

You blocked the wrong level. You were one level off.

Nice hydrolocation.

[EXIT]

The feedback/self-debriefing/after-action review screen generated by the automated scoring algorithm

```

20 practice minutes remain
40 practice blocks remain
3115 seconds viewing IT videos
5975 seconds practicing blocks
2425 seconds using replay
1108 seconds practicing skills
8/15/2016 4:01:00 PM 240
8/16/2016 3:54:26 PM 161
8/19/2016 3:42:42 PM 89
8/19/2016 4:07:49 PM 64
8/22/2016 3:18:05 PM 72
8/22/2016 4:14:47 PM TestBlock3
8/22/2016 4:21:52 PM TestBlock4
8/22/2016 4:27:15 PM TestBlock1
8/22/2016 4:29:35 PM TestBlock2
8/22/2016 4:32:03 PM TestBlock6
8/22/2016 4:35:27 PM TestBlock5

```

Text log of a participant's progress through the curriculum

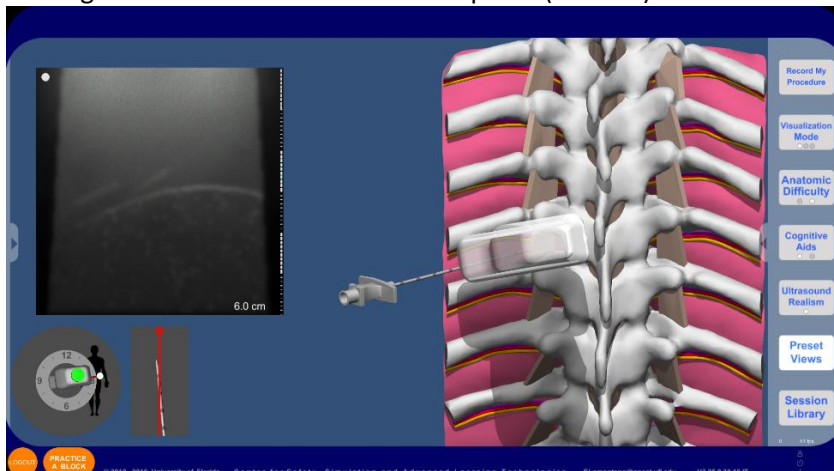
Participant	Group	Task	Technique	Procedure	Requested Side	Requested Level	Needle R	Penalty: E	Session Seconds	Ultrasound Used	Penalty: Inaj	Penalty: Too Much Time	Bone Strikes	Penalty: Tc
Cx	C	TestBlock3	USAssisted	ThoracicParavertebral	Left	T5	Yes	0	386.5	yes	413.1	4	10	2
Cx	C	TestBlock4	USAssisted	ThoracicParavertebral	Right	T5	Yes	0	243	yes	126.1	8	50	5
Cx	C	TestBlock1	USGuided	ThoracicParavertebral	Left	T3	Yes	0	84.4	yes	0	0	0	1
Cx	C	TestBlock2	USGuided	ThoracicParavertebral	Right	T3	Yes	0	75.4	yes	0	0	0	1
Cx	C	TestBlock6	Landmark	Epidural	Mid	T6	Yes	0	148.9	no	28.9	1	0	2
Cx	C	TestBlock5	USAssisted	Epidural	Mid	T4	Yes	0	332	yes	304	16	550	2
Bz	B	TestBlock3	USAssisted	ThoracicParavertebral	Left	T7	Yes	0	39.8	yes	0	0	0	0
Bz	B	TestBlock1	USGuided	ThoracicParavertebral	Right	T5	Yes	0	122.4	yes	0	2.4	2	0
Bz	B	TestBlock2	USGuided	ThoracicParavertebral	Left	T6	Yes	0	136.3	yes	0	16.3	0	0
Bz	B	TestBlock4	USAssisted	ThoracicParavertebral	Right	T4	Yes	0	124.7	yes	0	4.7	4	10
Bz	B	TestBlock5	USAssisted	Epidural	Mid	T5	Yes	0	68.6	yes	0	0	5	0
Bz	B	TestBlock6	Landmark	Epidural	Mid	T6	Yes	0	33.3	no	0	0	3	0

Formatted spreadsheet output of ongoing study data (dynamically generated; truncated)

- We created and 3D printed a second modular test anatomy block that is an 85% scale, mirrored model of the practice anatomy module for the final exam stage of the RA simulator learning outcome study. The test block contains different anatomy and distances for the final exam, so that users are tested on a different, more difficult patient. For our study, we color-coded the blocks.

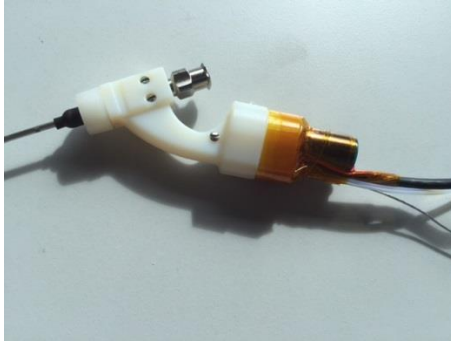


- We built a second modular simulator platform for the RA and CVA studies that will be conducted off-site.
- We **reformatted and downsized** the anatomic module for the CVA simulator so that it fits on the redesigned/enhanced modular stand. See Figure 2a
- Cognitive aids.** We added user-toggled (4th button from top on right column of buttons) cognitive aids to act as “training wheels” for novices. Two cognitive aids are displayed at the bottom left of the screen below. The left one shows a virtual probe and its orientation. The right one represents the alignment between the insonation plane (red line) and the needle (white line).



13. Created a **plug-in for the Ascension 3D Guidance system** for our simulation software suite
14. Designed and implemented a **SMARTS (System of Modular Augmented Reality Tracked Simulators) rapid development platform** with software plug-ins.

- a. **Interoperable tracked tools.** As an example, the needle was re-designed to be application-agnostic and interchangeable between SMARTS-compliant simulators, irrespective of the application. The modular needle hub was also redesigned to be more robust with better registration and sensor protection.



- b. **Reduced simulator weight.** When packed in its mil spec case, our simulators now meet both size ($L + W + H \leq 60$ ") and weight (≤ 50 lbs) restrictions for airline checked luggage.
- c. Redesigned hardware tracking box to be smaller, lighter, and quicker to assemble. New metal box below has better EMI noise shielding and is lighter than previous Plexiglas box.



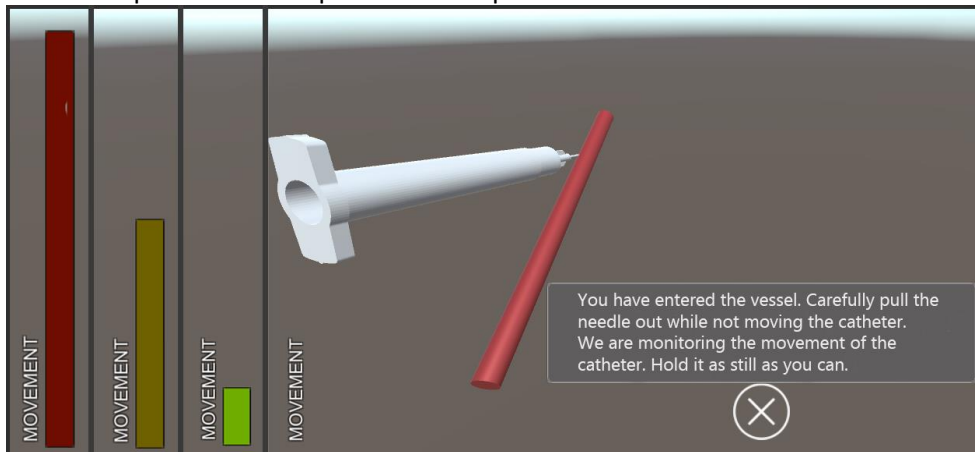
- d. **SMARTS modular stand upgrade:** we redesigned the modular stand to be made out of tough ABS plastic. It is lighter and easier to make.



15. We refined the modular stand design to allow for more rotation and faster physical swapping (< 1 minute) of different anatomic modules by redesigning the quick release spring mechanism (white latch engaging in blue receptacle).



16. We reformatted and downsized the anatomic module for the CVA simulator module (see Figure 2a) so that it fits on the redesigned/enhanced SMARTS modular stand.
17. We developed, built and deployed an ultrasonography skills trainer
18. We developed and built a proof of concept IV line insertion trainer



19. **Upgraded tracking system** to work with a smaller, lighter tracking transmitter that is also more accurate. Developed in-house signal filters that allow needle tracking sensors to work with the smaller transmitter. Upgraded firmware to work with the custom filters.
20. **Upgraded electromagnetic interference shielding** was added to the needle, tracked camera, simulated ultrasound probe, microcontroller assembly, and tracking hardware box. The shielded cables are also easier to assemble.
21. Designed a microcontroller printed circuit board for faster manufacturing and outsourcing.
22. Changed the connectors from the tracked tools to the microcontroller to an industry standard.

Opportunities Provided for Training and Professional Development
Year 2 (8/1/2015-7/31/2016)

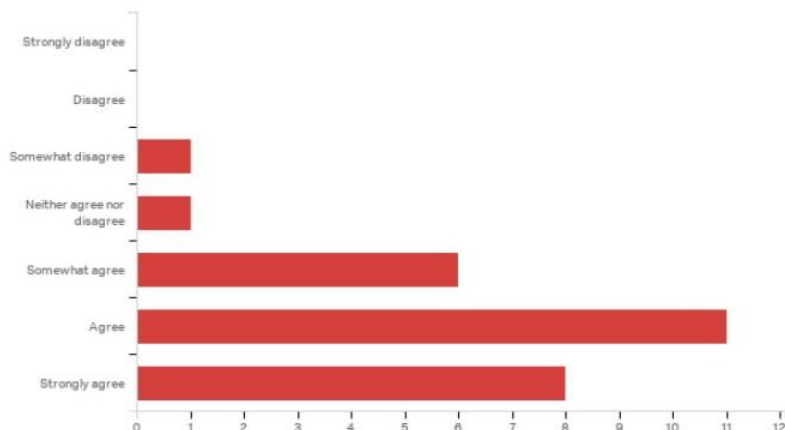
The Phase I mixed simulators were demonstrated and/or used during Year 2 of grant W81XWH-14-1-0113 per table below.

Institution	Location	Simulators	Dates	Number of trainees	Point of Contact/ Clinician
Stanford Medicine X Ed meeting	Palo Alto, CA	RA, CVA simulators	September 2015	~ 30 Simulator design workshop	Lampotang Larry Chu, MD
Veterans Health Administration SimLearn simulation center	Orlando, FL	RA, CVA and ultrasonography skills	October 2015	3 ~ 4	Haru Okuda Arranged by Sotomayor, STTC
Moffitt Cancer Center	Tampa, FL	RA	October 2015	~50	Barys Ihnatsenka, MD
American Society of Anesthesiologists (ASA) annual meeting	San Diego, CA	Ultrasonography skills and RA Scientific & Educational Exhibit	October 2015	~30	Lampotang Lizdas
ASA annual meeting, JAVMed booth	San Diego, CA	RA	October 2015	~50	B. Ihnatsenka, MD D. Edwards, MD
ASA annual meeting, Regional Anesthesia workshop	San Diego, CA	RA	October 2015	~50	B. Ihnatsenka, MD
ASA annual meeting, Poster presentation	San Diego, CA	RA	October 2015	~20	Lampotang
Naval Medical Center	San Diego, CA	RA and ultrasonography skills	10/26/15 to mid-December 2015	~ 10 anesthesia residents	Cdr. Justin Heil, MD, USN Anesthesiologist
Veterans Administration SimLEARN	Orlando, FL	RA, CVA and ultrasonography skills	November 24, 2015	~ 3 - 4	Lizdas Lampotang
University of Florida (UF), Inauguration of President Fuchs	Gainesville, FL	RA, CVA and ultrasonography skills	12/2 to 12/3, 2015	~30	Lizdas DeStephens Lampotang

University of Florida (UF), UF Health	Learning outcome study 2014-U-0658	RA	12/12/2015 to now	~ 10 anesthesia residents	B. Ihnatsenka, MD
University of Southern California	Los Angeles, CA	RA and CVA	January 2016	~ 10	Lampotang
GatorRAP	Orlando, FL	RA and CVA	3/5 to 3/6/2016	~95	B. Ihnatsenska, MD Albert Robinson, MD
University of Pennsylvania	Philadelphia, PA	RA	March 2016	~ 30	Yuri Zasimovich, MD
Fort Detrick	Frederick, MD	RA, CVA and ultrasonography skills, SMARTS rapid development platform	3/29/2016	~ 10	Lampotang
American Society for Regional Anesthesia and Pain Medicine	New Orleans, LA	RA	3/31-4/2/2016	~ 100	B. Ihnatsenska, MD
Walter Reed National Military Medical Center	Washington DC	RA	4/15-5/2/2016	~7	Cdr. Michael Kent, MD, USN Anesthesiologist
Brooke Army Medical Center	San Antonio, TX	CVA, RA and ultrasonography skills	4/19 to 6/10/2016	~23	Lampotang Col Craig McFarland, MD
Wilford Hall Ambulatory Surgical Center	San Antonio, TX	CVA, RA and ultrasonography skills	May 2016	~10	Ruben Garza
Society for Ambulatory Anesthesia	Orlando, FL	RA	5/5 to 5/7/2016	~45	B. Ihnatsenska, MD
Villanova University	Villanova, PA	CVA	5/1-5/15/2016	~12	Major Michael Scully, CRNA
Veterans Affairs Medical Center	Wilmington, DE	CVA	May 2016	~7	Major Michael Scully, CRNA
Florida Society of Anesthesiologists	West Palm Beach, FL	RA	6/10 to 6/12/2016	~60	B. Ihnatsenska, MD
First Maternal and Infant Hospital	Shanghai, China	CVA and RA	6/19 to 6/24/2016	~10	Lampotang
Association of Anesthesiologists of Mauritius	Moka, Mauritius	CVA, RA and ultrasonography skills	7/21/2016 7/28/2016	25 ~25	Lampotang

Examples of the feedback received from the external evaluation sites via an online Qualtrics survey tool at https://ufl.qualtrics.com/SE/?SID=SV_8uLi3fda221ayR7 are below.

Q8 - The simulator offers an overall realistic representation of the procedure.



Answer	%	Count
Strongly disagree	0.00%	0
Disagree	0.00%	0
Somewhat disagree	3.70%	1
Neither agree nor disagree	3.70%	1
Somewhat agree	22.22%	6
Agree	40.74%	11
Strongly agree	29.63%	8
Total	100%	27

Year 1 (8/1/2014-7/31/2015)

The Phase I Thoracic Regional Anesthesia (RA) mixed simulator was used during Year 1 of grant W81XWH-14-1-0113 at the University of Florida (UF) (approximately on 5 occasions) and the Massachusetts General Hospital (three times: 5/12-17/2014; 2/4/15; 5/20/15) for resident and faculty training. It was also extensively demonstrated as a compact, transportable, turnkey system at the World Congress of Regional Anesthesia and Pain Therapy (WCRAFT, Cape Town, South Africa, November 23-28, 2014), in the Government Corral at the International Meeting on Simulation in Healthcare (IMSH, New Orleans, LA, January 11-13, 2015), 3rd Annual Acute Pain Medicine & Regional Anesthesia Conference (Baltimore, MD, February 14-15, 2015) and GatorRAP (Gainesville, FL, February 21, 2015) meetings. The GatorRAP 2-day workshop focuses on regional anesthesia techniques and makes use of cadavers, live animal models, live human models and part task trainers including our simulators; the audience includes practitioners of regional anesthesia for human and veterinary medicine. Our simulators (2 RA simulators and one cross-sectional literacy trainer) were well received by both audiences. During WCRAFT, our RA simulator was also used extensively (3 days) at the University of Stellenbosch Tygerberg campus for hands-on workshops and also at the Cape Town International Convention Centre.

Our CVA simulator was used with IRB 02 approval (2013-U-1025) and informed consent by 76 study participants at the University of Florida allowing them to become more familiar with the relevant anatomy, strategy, techniques and approaches for CVA as well as the physics and anomalies of ultrasound imaging. The breakdown of the 76 participants trained in Central Venous Access via our CVA simulator is as follows:

- 6 Anesthesia Faculty members

- *1 Anesthesia Attending*
- *14 Interns/PGY1 (Post Graduate Year 1)*
- *10 CA1/PGY2 (Clinical Anesthesia Year 1/ Post Graduate Year 2)*
- *16 CA2/PGY3 (Clinical Anesthesia Year 2/ Post Graduate Year 3)*
- *13 CA3/PGY4 (Clinical Anesthesia Year 3/ Post Graduate Year 4)*
- *7 Fellows/PGY5 (Post Graduate Year 5)*
- *6 CRNAs (Certified Registered Nurse Anesthetists)*
- *3 Medical Students*

Dissemination to Communities of Interest

Year 2 (8/1/2015-7/31/2016)

Our turnkey simulators were loaned for evaluation for extended periods of time to:

- Naval Medical Center, San Diego, CA
- Walter Reed National Military Medical Center, Bethesda, MD
- Brooke Army Medical Center, San Antonio, TX
- Wilmington Delaware Veterans Affairs Medical Center, Wilmington, DE

An RA-simulator based Qualtrics quiz on performing the Thoracic ParaVertebral Block (TPVB) was placed online on March 15th, 2016. This online quiz has been used by clinicians and trainees at the four military sites that beta tested our simulators.

MCQ Test for TPVB Curricula 1 and 2:

http://survey.az1.qualtrics.com/SE/?SID=SV_0vVfq13RsvPSW1L

A manuscript is in the final stages before submission for peer review by the journal *Anesthesia & Analgesia*. The manuscript describes a learning outcome study conducted on the CVA simulator on supraclavicular access to the subclavian vein – see flowchart of study protocol below. Augmentation of the simulator via 3D, color-coded, real-time visualization did not appear to make a difference in performance and seem to indicate that there is a need for instruction and a curriculum and/or that the supraclavicular approach is so straightforward that the visualization makes no difference. These learning outcomes have motivated us to explore integrated tutors for our AR simulators. Preliminary data that are excerpted from the manuscript are included below.

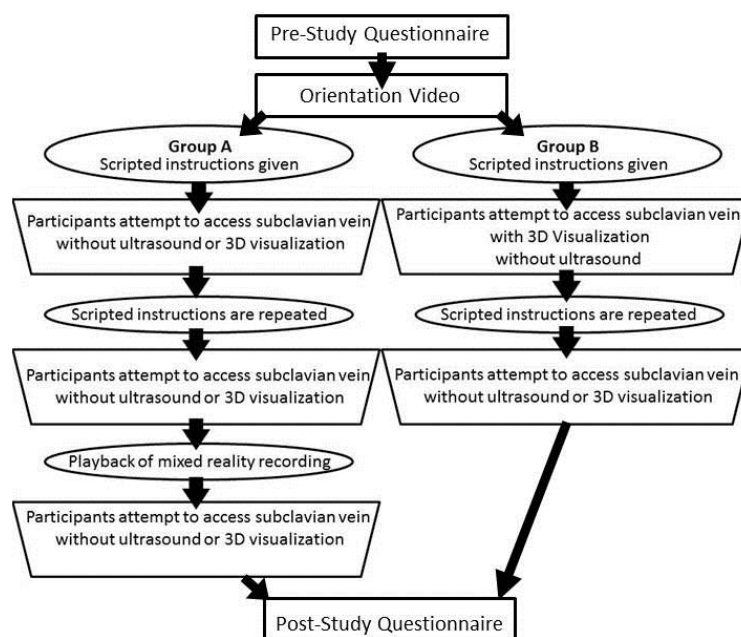


Table 1. Descriptive statistics for the supraclavicular approach experimental groups (with 3D visualization and without). Values are scores generated by an automated scoring algorithm.

Trial	No Visualization (n = 42)				Visualization (n = 27)			
	M	SD	95% CI	Mdn	M	SD	Lower 95%	Mdn
Baseline	533.1	108.8	(499.2, 567.0)	565.6	577.7	16.6	(571.2, 584.3)	584.8
Final Trial	568.7	42.1	(555.5, 581.8)	584.1	576.4	42.7	(559.5, 593.2)	590.2

Table 2. Complications and scoring penalties prior to simulator-based training (Baseline) and after simulator-based training (Post-Intervention)

Trial	Backwall Errors	Pneumothorax	Arterial Puncture
Baseline	8	3	1
Post-Intervention	4	1	0

Table 3. Errors, Penalties and Complications by Approach (N=69)

	Supraclavicular			Internal Jugular (IJ)			Infraclavicular (SC)		
	Visualization	No visualization	Total	Visualization	No visualization	Total	Visualization	No visualization	Total
Backwall									
Baseline	1	7	8	6	10	16	8	3	11
Post-intervention	1	3	4	5	4	9	2	2	4
Pneumothorax									
Baseline	0	3	3	1	0	1	2	4	6
Post-intervention	0	1	1	0	0	0	1	1	2
Arterial Puncture									
Baseline	0	1	1	1	5	6	0	1	1
Post-intervention	0	0	0	2	1	3	0	1	1
Extra Attempts									
Baseline	0	3	3	2	3	5	21	17	38
Post-intervention	1	0	1	0	1	1	14	6	20

A second manuscript describing results from a learning outcome study of our CVA simulator for the IJ and infraclavicular approaches to the subclavian vein is in a more preliminary state and will be submitted for peer-reviewed publication in year 3.

Our simulators are an integral part of demonstrations we conduct on a regular basis for our simulation center visitors that include high school students, STEM programs and science programs for high school students, programs for minority and under-represented students, medical school applicants, residency program applicants, visiting professors, medical industry executives and engineers and educators including high school science teachers.

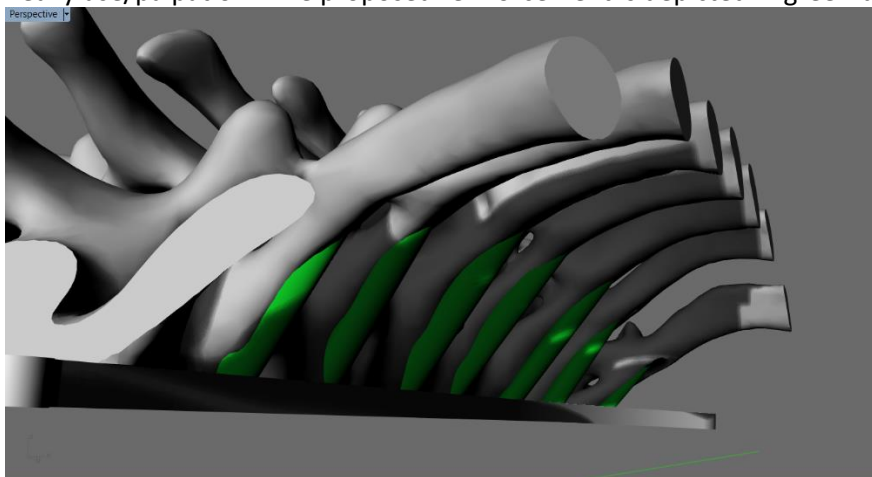
Year 1 (8/1/2014-7/31/2015)

Results were disseminated via the demonstrations, meetings and workshops described above. In addition, the simulators are an integral part of demonstrations we conduct on a regular basis for our simulation center visitors that include high school students, STEM programs and science programs for high school students, programs for minority and under-represented students, medical school applicants, residency program applicants, visiting professors, medical industry executives and engineers and educators including high school science teachers.

*In addition, the real-time, 3D, color visual augmentation in our RA simulator helped a local RA and thoracic paravertebral block (TPVB) SME invent a new technique for TPVB: the Sagittal Paramedian (SP) Oblique (SP-Oblique TPVB). This innovative development (and possibly a first) of a simulator helping to invent a new technique that is efficacious on patients was submitted on 3/6/15 to the journal *Simulation in Healthcare* for peer-reviewed publication as an Empirical Investigation paper. The paper received generally positive reviews; the editor has suggested splitting the paper (which did contain a lot of information) into three peer-reviewed publications.*

Plan for Next Reporting Period to Meet Goals & Objectives

- We will finalize the patient outcomes study. We plan to submit another IRB01 (prospective instead of retrospective) application in year 3 in preparation for the patient outcomes study. Our goal is to obtain IRB01 approval by December 2016 so that we can start collecting and doing preliminary analyses on pre-intervention (retrospective) patient and complication data related to CVA.
- We plan to complete the needs assessment for the EVD, prostate biopsy and chest tube insertion simulator in 2017.
- We will start to design the transfer of practice and ROI outcomes studies.
- We will redesign the CVA modular anatomy to be lighter and stronger. We will change the material to 3D printed nylon. Our first modular CVA anatomy was found to have inadequate tissue feel; currently undergoing design modifications to include better tactile landmarks and reduced give over the puncturable skin area.
- We will reinforce the cantilevered ribs on the RA simulator as some ribs have broken during heavy use/palpation. The proposed reinforcement is depicted in green below the ribs.



- We will repurpose elements of the RA simulator such as integrated tutor, procedure agnostic mini-skills, and in-program quiz for the CVA outcome study

- We will design and submit a learning outcome study to UF IRB 02 and HRPO for a prospective study of the reduced/modular format CVA simulator.

IMPACT:

Year 2 (8/1/2015-7/31/2016)

The results from our learning outcome study using the CVA simulator indicate that the supraclavicular approach to the subclavian vein may be an inherently safe approach (see Table 3) to use for central venous access that is not used as frequently as it might be indicated because most clinicians are unfamiliar with the technique. The CVA simulator could be a tool to provide military and civilian clinicians exposure and familiarity with supraclavicular access to the subclavian vein. Our unexpected results seem to be consistent with two peer-reviewed papers:

- Czarnik T. et al: Supraclavicular Approach Is an Easy and Safe Method of Subclavian Vein Catheterization Even in Mechanically Ventilated Patients: Analysis of 370 Attempts. *Anesthesiology* 2009; 111:334–9
- Shannon P. et al: Supraclavicular Subclavian Vein Catheterization: The Forgotten Central Line. *Western Journal of Emergency Medicine* 2009, 10(2); <http://escholarship.org/uc/item/8kf7q46w>

Year 1 (8/1/2014-7/31/2015)

The modularity of the modular stand allowed us to readily implement a cross-sectional literacy trainer that was exhibited together with our RA and CVA simulators at the Government Corral at IMSH in New Orleans, LA from January 11 to 13, 2015. The cross-sectional trainer has been extremely well received by practicing clinicians and medical and physician assistant students alike. It has sensitized medical educators and instructors to the fact that the fundamentals of cross-sectional literacy have been shortchanged, if addressed at all, in most healthcare curricula. Cross-sectional literacy underpins the ability of clinicians to interpret imaging modalities such as ultrasound imaging that produce 2D cross-sections out of 3D objects and to use ultrasound guidance to safely steer needles to their intended targets. The cross-sectional literacy trainer is intentionally devoid of anatomy and is thus procedure-agnostic. It will be applicable to all medical and healthcare disciplines where medical imaging that produces 2D cross-sections (such as ultrasound imaging) are produced. While the cross-sectional literacy and ultrasonography skills trainer is a spin-off of our DoD research and facilitated by the availability of the modular stand, we are not sure whether we need to continue reporting on this technology/application in future reports as part of the DoD grant, since our formal request to swap the cross-sectional literacy trainer for the chest tube insertion trainer was denied. See http://simulation.health.ufl.edu/research/US_Trainer_Demo_Video.wmv.

The real-time, 3D, color visual augmentation in our RA simulator helped our regional anesthesia SME invent a new technique for thoracic paravertebral block (TPVB): the Sagittal Paramedian (SP) Oblique (SP-Oblique TPVB). This technique developed via an anatomically correct simulator with visual augmentation has been tried on patients and found to be efficacious.

CHANGES/PROBLEMS:

Year 2 (8/1/2015-7/31/2016)

No substantial changes were made.

We were instructed to not acknowledge DoD support for DoD-funded work (post-intervention data processing and statistical analysis and manuscript preparation) for 2 manuscripts we are submitting for publication because the study data was collected prior to the official start of the DoD grant (8/1/2014) with UF IRB02, but therefore not HRPO, approval.

Year 1 (8/1/2014-7/31/2015)

Change of Deliverable (approved by DoD on 4/22/15)

We made a formal written request to replace the proposed Focused Assessment with Sonography of Trauma (FAST) trainer in the original proposal with a mixed reality simulator for TransRectal UltraSound (TRUS)-imaged, manually-guided needle biopsy of the prostate. This request was made because the accuracy and uniform distribution of sampling during TRUS-imaged, manually-guided prostate needle biopsy trainer is poor, an undesirable state of current practice that is particularly relevant to the aging male population in the VA Health system and therefore to the DoD and also for the aging general male civilian population at large. Our request to replace the FAST trainer with the prostate biopsy trainer received approval via an email from Mr. Meinberg on 4/22/15.

While the change to a prostate biopsy simulator will most impact Phase II deliverables to DoD, it will also impact Phase I deliverables because, as a result, we will, in Phase I, conduct needs assessment for the prostate biopsy trainer, not for the FAST trainer.

PRODUCTS:

Year 2 (8/1/2015-7/31/2016)

Number of peer-reviewed publications (include ones that are pending publication): 6

MHSRS Abstract: 1

ASA Abstract: 1

UFCOM Celebration of Research: 1

IMSH 2016 DOD Interactive Demo Abstract: 1

ASRA Abstract: 1

- 1 abstract presented 8/19/15 at Military Health System Research Symposium (MHSRS) meeting
- In Progress Review (IPR) presented at TATRC offices, Ft. Detrick, MD on 3/29/2016
- 90-minute workshop on simulator design presented at Medicine X Ed, Stanford on 9/24/2015.
- RA simulator used in hands-on workshops at Moffitt Cancer Center, Tampa, FL on 10/3 and 10/4
- 1 abstract on RA simulator helping to develop modified TPVB technique presented 10/26/15 at American Society of Anesthesiologists (ASA) annual meeting, San Diego, CA
- 1 scientific exhibit presented for 3 consecutive days (10/24-10/26/15) at ASA annual meeting
- RA simulator used in Teleflex booth for 3 days (10/24-10/26/15) at ASA annual meeting
- RA simulator used in JAVMed booth for 3 days (10/24-10/26/15) at ASA annual meeting
- RA simulator used in hands-on workshop on 10/27/15 at ASA annual meeting
- A modular set of interoperable tracked tools (needle, ultrasound probe and virtual camera controller/Tangible User Interface) was built and evaluated.
- Dr. Sotomayor, Dr. Lampotang and David Lizdas demoed the CVA, RA and US skills simulators at the Veteran's Health Affairs SimLEARN on 11/24 near Orlando airport
- The RA simulator and Cross-Sectional literacy simulators were evaluated at Naval Medical Center San Diego from October 26, 2015 to mid-December 2015
- Implemented 64-bit plug-in for tracker; the frame rate on the CVA simulator visualization almost doubled as a result of migrating from 32-bit to 64-bit and rendering in Unity 5 instead of 4.
- Submitted on short notice at DoD's request an abstract "SMARTS: MODULAR STAND AND INTEROPERABLE TRACKED TOOLS FOR AUGMENTED REALITY PROCEDURAL SIMULATORS" on 11/18/15 for the IMSH 2016 DoD Interactive Demo Area (Government Corral).
- Dr. Ihnatsenka started preliminary work with residents on study 2014-U-0658 on 12/12/15
- A continuation patent application on mixed reality simulators for blind and guided medical procedures was filed by UF on 12/28/15 as continuation to an original patent filed in 2010 prior to DoD award

- Our augmented reality procedural simulators were selected to be the sole exhibit of the UF College of Medicine at the inauguration ceremonies on 12/2 and 12/3/2015 of the new president of the University of Florida, Dr. Kent Fuchs
- We implemented adequately realistic fluoroscopic (NOT UltraSound) imaging with the 64-bit version of Unity
- Edwards DA, Vazquez R, Lizdas DE, Lampotang S: A mixed reality simulator augmented with real time 3D visualization helps develop a modified technique for accessing the thoracic epidural space; abstract submitted to ASRA on 12/31/15
- An 85% scale, mirrored, 3D-printed spine that is part of the protocol for the RA simulator learning outcomes study was received 1/7/16
- A provisional patent on cognitive aids (UF1220) was converted to a utility patent on 1/11/16
- The first draft of the needs assessment for the chest tube insertion simulator was completed by Dr. Choi on 1/15/16 based on a simulator needs assessment template created by Dr. Lampotang
- The redesign of the central venous access (CVA) simulator to fit the modular mount was completed
- Small form factor DoD CVA simulator anatomical block was finalized and 3D printed on 1/5/16
- A quick-release mechanism for locking different anatomical blocks to a SMARTS stand was implemented.
- All simulators were rewired with shielded wire to harden against interference from random electrical noise
- Lampotang, Lizdas, Freytes demoed the modular sims to a potential industry licensee on 10/21/2015
- Edwards DA, Vazquez R, Lizdas DE, Lampotang S: A mixed reality simulator augmented with real-time 3D visualization helps develop a modified technique for accessing the thoracic epidural space; abstract submitted to ASRA, 12/31/15
- 3/18-19/16 – Army RA workshop, Baltimore
- 4/18-24 – Evaluation of RA simulator at Walter Reed (Led by Cdr. Michael Kent, MD, USN)
- 4/20/16 – Two PowerPoint presentations by Dr. Barys Ihnatsenka for use with our RA simulator were posted online at http://simulation.health.ufl.edu/education/Curriculum1_lecture_B-1.pptx ; and http://simulation.health.ufl.edu/education/Curriculum1_lecture_A-1.pptx
- Mike Kent demoed RA simulator to 6 residents and 4 staff members at Walter Reed
- Brooke Army Medical Center evaluation of CVA simulator by administration director Robert Coffman and Colonel McFarland
- CVA Simulator evaluation in a simulator workshop at Villanova by Major Scully
- CVA simulator evaluation at Wilmington Delaware VAMC by Major Scully
- Received 17 Post-Simulator training surveys from Villanova; simulator returned to UF on 5/17/16.

Year 1 (8/1/2014-7/31/2015)

- *Lampotang S, Lizdas DE, Ihnatsenka B: Basics of US in RA. Proceedings of the World Congress of Regional Anesthesia and Pain Therapy (WCRAFT), 2014*
- *Lampotang S, Lizdas DE, Ihnatsenka B: A mixed reality simulator of thoracic RA. Proceedings of the World Congress of Regional Anesthesia and Pain Therapy (WCRAFT), 2014*
- *Lampotang S, Le-Wendling L, Coleman CJ, Lizdas DE, Ihnatsenka BI: Real-time 3D visualization in a mixed simulator helps develop a modified regional anesthesia technique. Submitted 3/6/15 to Simulation in Healthcare; favorable review received 5/20/15; need to split manuscript into 3 publications; acknowledgement of federal support (yes).*

- *Ihnatsenka B, Le-Wendling L, Coleman CJ, Lizdas DE, Lampotang S: A mixed reality simulator augmented with real-time 3D visualization helps develop a modified thoracic paravertebral block, Submitted 4/6/15 to American Society of Anesthesiologists (ASA) 2015 annual meeting; accepted 6/18/15 for poster presentation*
<http://www.asaabstracts.com/strands/asaabstracts/printAbstract.htm?jsessionid=698B518CD51AFF97B17E7A229AA125D0?index=0&year=2015&absnum=4398&type=search>
- *Lampotang S, Lizdas DE, Cooper LA, Gravenstein N, Ihnatsenka B: A cross-sectional literacy and ultrasound skills trainer. Scientific & Educational Exhibit submitted 4/6/15 to American Society of Anesthesiologists 2015 annual meeting; accepted for presentation as a Scientific & Educational Exhibit on 3 consecutive days (10/24-10/26/2015) at the San Diego Convention Center*
- *Lampotang S, Lizdas DE, Cooper LA, Gravenstein N, Robinson A: Mixed Reality Simulation for Training Reservists and Military Medical Personnel in Subclavian Central Venous Access, submitted 4/7/15 to Military Health System Research Symposium (MHSRS); presented by Samsun Lampotang, PhD as a poster at the Military Health System Research Symposium (MHSRS) on 8/19/2015, Marriott Hotel, Ft. Lauderdale, FL*
- *Lampotang, Lizdas, Ihnatsenka: A mixed reality simulator of thoracic regional anesthesia. Exhibited at UF BME PhD Recruitment day (2/20/15)*
- *Ihnatsenka B, Le-Wendling L, Coleman CJ, Lizdas DE, Lampotang S: A mixed reality simulator augmented with real-time 3D visualization helps develop a modified thoracic paravertebral block. Exhibited at Dept. of Anesthesiology Celebration of Research (4/29/15)*
- *Lampotang S, Lizdas DE, Cooper LA, Gravenstein N, Ihnatsenka B: A cross-sectional literacy and ultrasound skills trainer. Exhibited at Dept. of Anesthesiology Celebration of Research (4/29/15) – Oral presentation*
- *3rd place award for oral presentation of “A cross-sectional literacy and ultrasound skills trainer” at the University of Florida Anesthesiology Department’s Celebration of Research 4/29/15*
- *Lampotang S, Lizdas DE, Cooper LA, Gravenstein N, Robinson A: Mixed Reality Simulation for Training Reservists and Military Medical Personnel in Subclavian Central Venous Access. Exhibited at Dept. of Anesthesiology Celebration of Research (4/29/15)*
- *A video of the new RA simulator design was uploaded to the web at*
http://simulation.health.ufl.edu/research/ra_sim.wmv
- *A modified technique for US-guided thoracic paravertebral block (TPVB), the Sagittal Paramedian Oblique technique was developed with the help of the 3D visualization in the RA simulator; a peer-reviewed Empirical Investigation paper was submitted on 3/6/15 to the journal Simulation in Healthcare to describe this potential first in simulation*
- *A US provisional patent application: Lampotang, Lizdas, Ihnatsenka: “Simulation Features Combining Mixed Reality and Modular Tracking” was filed on 1/10/15 and assigned Serial No. 62/101,997 UF.1220P (UF#15508) prior to the Government Corral exhibit at IMSH in New Orleans. This patent application served two purposes: protect UF intellectual property (IP) before public disclosure at the Government Corral and establish the IP that was already in UF’s possession before the 8/1/2014 start of the DoD funding.*
- *A mixed reality cross-sectional literacy and ultrasonography skills trainer was developed as a proof of concept of the flexibility and rapid development platform made possible by a modular stand design with an imbedded tracker. The trainer was exhibited at the Government Corral at IMSH in New Orleans (January 11-13, 2015). The cross-sectional literacy trainer has been accepted as a Scientific & Educational exhibit and will be exhibited on 3 consecutive days (10/24-*

26/2015) at the October 2015 Annual Meeting of the American Society of Anesthesiologists in San Diego, CA.

PRESENTATIONS:

Year 2 (8/1/2015-7/31/2016)

- Mixed Reality Simulation for Training Reservists and Military Personnel in Subclavian Central Venous Access, Poster MHSRS-15-0857 presented at the Military Health System Research Conference 2015, Ft. Lauderdale, Florida, 8/19/2015
- Ihnatsenka B, Le-Wendling L, Coleman CJ, Lizdas DE, Lampotang S: A mixed reality simulator augmented with real-time 3D visualization helps develop a modified thoracic paravertebral block, American Society of Anesthesiologists (ASA) 2015 annual meeting; 10/26/2015
- Lampotang, Gravenstein, Ihnatsenka, Lizdas: A cross-sectional literacy and ultrasound skills trainer, Scientific Exhibit, American Society of Anesthesiologists 2015 annual meeting, 10/24-26/2015
- Lampotang: 90-minute workshop on simulator design, Stanford Medicine X Ed, Stanford, California, 9/24/2015
- Ihnatsenka: taught with the RA simulator, Moffitt Cancer Center, Tampa, FL on 10/3-4/2015
- Sotomayor, Lampotang and Lizdas: CVA, RA and US skills simulators, Veteran's Health Affairs SimLEARN, Orlando, Florida, 11/24/2015
- Lampotang, Lizdas, DeStephens: Augmented reality procedural simulators were selected to be the sole exhibit of the UF College of Medicine inauguration ceremonies of the new president Dr. Kent Fuchs, Gainesville, Florida, 12/2-3/2015
- Lampotang: presented the mixed reality simulator among other technologies at a lecture at the University of Southern California Institute of Creative Technologies (ICT), Los Angeles, California, 1/28/2016
- Ihnatsenka: 2 RA and 1 CVA simulators exhibited, GatorRAP, Orlando, FL, 3/5-6/2016
- Lampotang: demo of the RA with intelligent tutor, the CVA, the SMARTS platform, Fort Detrick, Maryland, 3/29/16
- Ihnatsenka, Demoed RA simulator, American Society for Regional Anesthesia and Pain Medicine, New Orleans, Louisiana, 3/31/16-4/2/16
- Zasimovich: demonstrated the RA simulator at workshop, University of Pennsylvania, Philadelphia, Pennsylvania, 4/16/16
- Ihnatsenka: Society for Ambulatory Anesthesia, Orlando, Florida, 5/5-7/16
- Ihnatsenka: RA Simulator Demonstration, Florida Society for Anesthesiologists, West Palm Beach, Florida, 6/10-12/16
- Lampotang: CVA and RA Simulator demonstration at opening of simulation center, Shanghai, China
- Lampotang: CVA, RA, and the US-Trainer were used in Mauritius for a clinical workshop, 7/21/16

Year 1 (8/1/2014-7/31/2015)

- Lampotang: "Basics of US in Regional Anesthesia" lecture, World Congress of Regional Anesthesia and Pain Therapy, Cape Town International Convention Centre, Cape Town, Republic of South Africa, 11/25/14
- Ihnatsenka, Yasimovich, Lampotang: Workshop using UF Regional Anesthesia simulator at Tygerberg Campus of the University of Stellenbosch, Cape Town, RSA, 11/25/14

- *Lampotang: “A mixed simulator of thoracic regional anesthesia” lecture, World Congress of Regional Anesthesia and Pain Therapy, Cape Town International Convention Centre, Cape Town, Republic of South Africa, 11/26/14*
- *Lampotang, Lizdas: Government Corral exhibit, International Meeting on Simulation in Healthcare, Ernest Morial Convention Center, New Orleans, LA, Jan 2015*
- *David Edwards, MD: RA simulator used at 3 different Harvard workshops at MGH (5/12-17/2014, 2/4/15 and 5/20/15)*
- *Patrick Tighe, MD: Hands-on demonstration of the Regional Anesthesia simulator at the 3rd Annual Acute Pain Medicine and Regional Anesthesia Course, Baltimore, MD, February 14-15, 2015*
- *Lampotang, Lizdas: GatorRAP workshop hands-on session 2/21/15*
- *Lampotang: “A Mixed reality simulator for Cross-Sectional/Ultrasound literacy” lecture, GatorRAP, Gainesville, FL, 2/22/15*
- *Barys Ihnatsenka, MD: lecture, 40th Annual meeting of the American Society of Regional Anesthesia, Las Vegas, NV, 5/16/15*
- *Lampotang: Hands-on workshop with RA and cross-sectional literacy trainers. Geisinger Health System, Danville, PA 6/3/2015*

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS:

Year 2 (8/1/2015-7/31/2016)

Major Michael Scully, CRNA has been collaborating with us on our simulators. He recently used our RA and CVA simulators at Villanova and at Wilmington Delaware VAMC to train his students.

David Edwards, MD, who has now moved from MGH to Vanderbilt continues to collaborate with us on our RA simulator.

Ascension/NDI is the supplier of the trackers and miniature magnetic 6-DoF sensors used in our mixed reality simulators. Their technical staff provided us with assistance when we had technical questions and extended loan of their latest products for evaluation.

The US Army Research Laboratory’s Simulation and Training Technology Center (STTC) is a sub-contractor on the award. Mr. Robert Pike is now our STTC POC and visited our lab on 8/31/16.

Year 1 (8/1/2014-7/31/2015)

David Edwards, MD, an assistant professor at Massachusetts General Hospital (MGH) borrowed our RA simulator for 3 separate mandatory faculty training sessions at MGH (5/12-17/2014; 2/4/15; 5/20/15) Ascension/NDI is the supplier of the trackers and miniature magnetic 6 DoF sensors used in our mixed reality simulators. Their technical staff provided us with assistance when we had technical questions and extended loan of their latest products for evaluation. Our close working relationship with Ascension/NDI is a win-win synergy. We are supplied with the latest products and line of sight of products in the pipeline. In turn, our research is a show case of what can be accomplished with Ascension/NDI products. As an example, Ascension invited us to exhibit our RA simulator at Ascension’s booth at IMSH in January 2015.

The US Army Research Laboratory’s Simulation and Training Technology Center (STTC) is a sub-contractor on the award.

INTERIM PROGRESS REVIEW

The PI, Samsun Lampotang, PhD, travelled to Ft. Detrick, MD to present, in person, progress on award W81XWH-14-1-0113 at an In Progress Review on 3/29/2016. As a result, the technical progress report for Quarter 4 is not included in this report because presentation at the IPR waives the need for the Q4 technical progress report.

PUBLICATION, ACKNOWLEDGEMENT, AND PUBLIC RELEASE

The required and relevant annotation was added to publications except in cases where the limited amount of words allowed for abstracts precluded the boilerplate language from being added. We obtained written permission from the program officer in those instances to omit the boilerplate text because of word count restrictions.